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CR-133578

IDENTIFICATION, DEFINITION AND MAPPING OF
TERRESTRIAL ECOSYSTEMS IN INTERIOR ALASKA

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July 31, 1973

Second Semi-Annual Technical Report, February-July, 1973
NASA Contract NAS5-21833
ERTS Project 110-3

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland 20771

(E73-10921) IDENTIFICATION, DEFINITION
AND MAPPING OF TERRESTRIAL ECOSYSTEMS IN
INTERIOR ALASKA Semiannual Technical
Report, Feb. - Jul. 1973 (Alaska Univ.,
Fairbanks.) 26 p HC \$3.50

N73-29270

CSCL 08B

G3/13

Unclas
00921

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. 6	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Identification, definition and mapping of terrestrial ecosystems in interior Alaska		5. Report Date July 31, 1973	
		6. Performing Organization Code	
7. Author(s) J. H. Anderson		8. Performing Organization Report No.	
9. Performing Organization Name and Address Institute of Arctic Biology University of Alaska Fairbanks, Alaska 99701		10. Work Unit No.	
		11. Contract or Grant No. NAS5-21833	
12. Sponsoring Agency Name and Address National Aeronautics and Space Adm. Goddard Space Flight Center Greenbelt, MD 20771		13. Type of Report and Period Covered II and 2/1/73-7/31/73	
		14. Sponsoring Agency Code	
15. Supplementary Notes One of 12 ERTS-1 projects conducted by the Univ. of Alaska Proj. GSFC # 110-3; Principal Investigator GSFC # UN 592			
16. Abstract A primary objective is to identify and analyze vegetation types in as great of detail as possible on ERTS imagery and to classify and delineate them through mapping. This is basic to the identification, definition and mapping of ecosystems. The second six months of this project dealt chiefly with photo-interpretation of ERTS scenes covering three interior Alaskan test areas, nos. 5, 6 and 8, and the development of vegetation mapping techniques. A new vegetation map of an area near Fairbanks was produced. Major conclusions are (1) the ERTS system is useful for regional scale studies of broadly defined Alaskan vegetation types, (2) the resolution and spectral capabilities of ERTS-1 MSS imagery in photographic formats is adequate for certain phytocenologic purposes and (3) preparation of an improved State vegetation map will be feasible.			
17. Key Words (Selected by Author(s)) Alaskan vegetation Boreal forest vegetation Vegetation mapping Alaskan ecosystems		18. Distribution Statement	
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 23	22. Price*

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1.

ERTS-1 Project 110-3: Identification, definition and
mapping of terrestrial ecosystems in interior Alaska

Semi-annual report, July 31, 1973

I. INTRODUCTION

This report summarizes work performed and conclusions reached during the second six months, February 1 through July 31, 1973, of contract no. NAS5-21833, ERTS-1 project 110-3, Identification, definition and mapping of terrestrial ecosystems in interior Alaska.

Activity during the report period involved chiefly the development of a procedure for identifying, defining and mapping vegetation types through direct visual interpretation of ERTS photographic products. An underlying thesis is that ecosystems are best recognized on the basis of vegetation types. Most work was with scene 1033-21011, covering an area immediately west of Fairbanks, for which a new, although preliminary vegetation map was drawn. This map is presented here. Several other scenes were studied for phytocenologic purposes and the findings are reported here. In addition, new scenes were selected, tentatively, for future use, including several for areas outside the test areas established earlier.

A major reorientation in ground control of ERTS image interpretations was made: Actual field work, which is time-consuming and costly, was nearly eliminated in favor of increased reliance on air photo studies. This seems appropriate now not only from a financial standpoint, but also in view of the abundant aerial photography, in addition to that provided by NASA-Houston, available in the files of various agencies, the great amount of which has only recently become known.

The second six months' work on this contract tended to confirm the general conclusions made after the first six months: (1) The ERTS system is useful for making regional scale studies of broadly defined Alaskan vegetation types. (2) The resolution and spectral information capabilities of ERTS-1 MSS imagery in photographic formats is adequate for certain phytocenologic objectives. (3) The ERTS system could permit the eventual vegetation and probably ecosystem mapping of Alaska in greater classificatory and spatial detail than was accomplished prior to ERTS. An additional conclusion is (4) that ERTS imagery is of little value to phenology in interior Alaska because of the rarity of useful repetitive imagery for most places. Finally, the second six months' work has led to a less complex data handling procedure than was proposed earlier, including the elimination of certain activities.

II. STATUS OF PROJECT

A. Objectives

The primary objective of this project is to identify and analyze vegetation types to the maximum extent possible with ERTS imagery and to classify and delineate them through mapping. Pursuit of this objective is considered a prerequisite for meeting the original proposal objectives which are:

1. development of a capacity for the identification and delineation of interior Alaskan ecosystems on ERTS-1 imagery through correlation of spectral signatures with vegetation, landform units and other ecosystem components represented in the test areas
2. development of a capacity for the recognition of diagnostic features useful in defining interior Alaskan ecosystems, including vegetation structure and composition and time of onset of plant growth, leaf development and cessation of growth (phenology)
3. development of a capacity for producing a map of interior Alaska showing the areal distribution and extent of ecosystem types represented in the test areas using ERTS-1 data covering the rest of the region
4. the evaluation of the usefulness of ERTS-1 imagery for determining certain parameters and biological processes in ecosystems, including (a) moisture conditions of the vegetation and soil, (b) nutritional status of the vegetation, (c) effects on vegetation and soil of disturbances resulting from construction activities, fire, disease and overgrazing, (d) standing crop biomass, (e) climatological factors including, at least, snow cover, (f) primary productivity and (g) recovery from disturbance and short-term plant succession

It is emphasized that the identification, definition and mapping of ecosystems depends largely on the identification, definition and mapping of vegetation types (= plant communities = phytocenoses), since vegetation is the most conspicuous and structurally and functionally important component of most terrestrial ecosystems. An ecosystem is a stand of vegetation plus the various animal and microbe populations and physical factors which interact with it or otherwise influence its being. Construction of an ecosystem map must begin with a vegetation map. The process may involve augmenting vegetation map unit designations and descriptions so that these express knowledge of ecosystem components additional to the vegetation, to the extent that available information on these other

components will allow.

During the report period a major objective was development of a vegetation map for an area near Fairbanks using scene 1033-21011, which has become one of the most important images in this project. Although only a preliminary map is finished, the working out of problems involving spectral unit recognition and delineation, identification of these according to vegetation type, classification of vegetation types, and transferring information from the ERTS image to a base map have involved a considerable amount of thinking and related physical activity. Work during the report period seems pertinent to the primary objective, stated above, in view of the fact that the fundamentals of a relatively straightforward and inexpensive procedure for identifying, delineating and mapping major vegetation types and ecosystems have been laid.

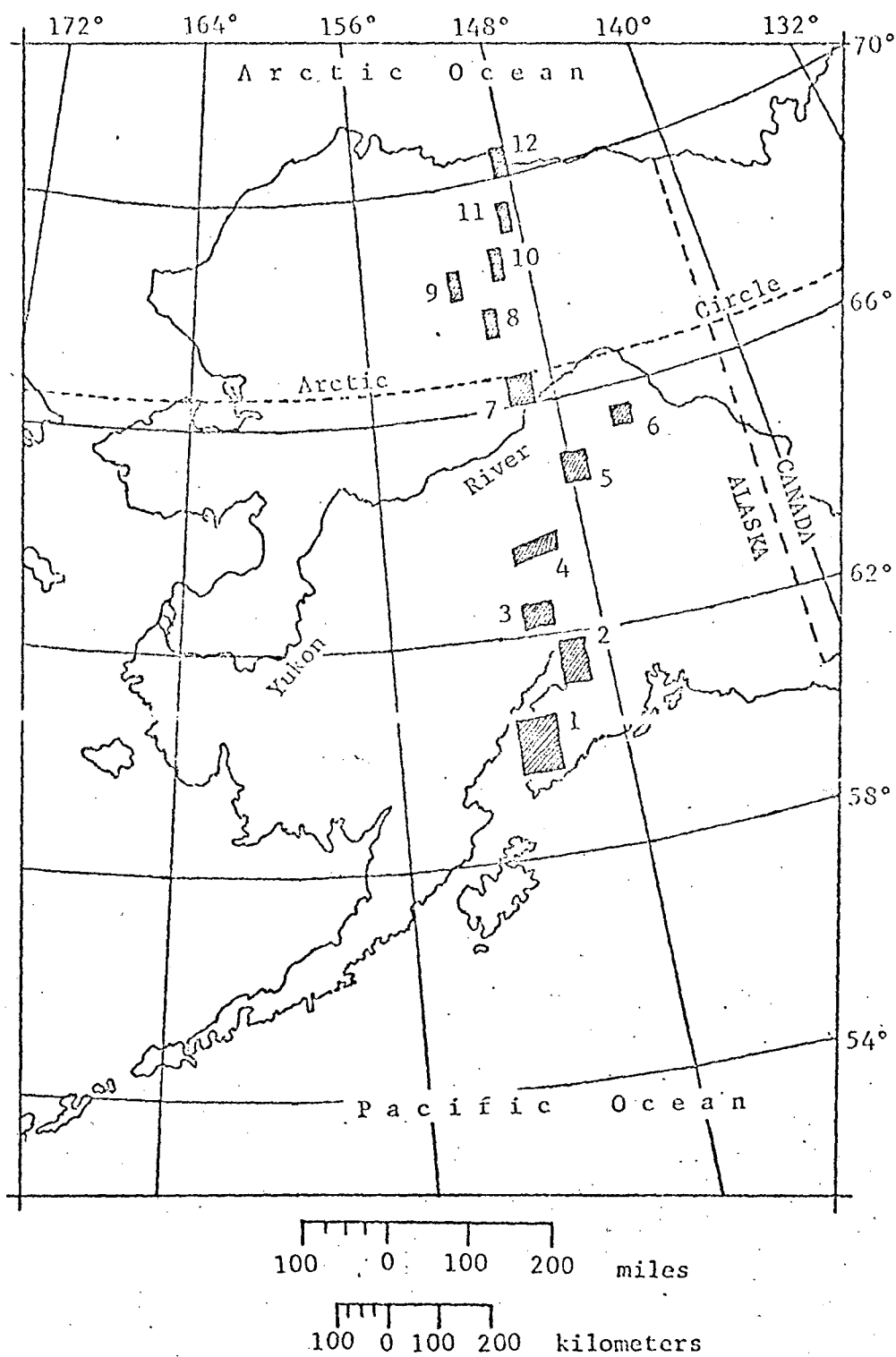
B. Accomplishments during the report period

1. continued examination and cataloging of incoming imagery; selection for analysis of a few scenes suitable on the basis of low cloud cover, area coverage and season

The following table lists the scenes meeting these requirements, including those selected during the first six-month report period. Scenes for test areas 1, 2 and 3, south of the Alaska Range, are not listed because these are the responsibility of project 110-2.

<u>SCENE ID #</u>	<u>TEST AREA</u>
1017-21115	8 - Wiseman (S Brooks Range)
1029-20381	6 - Eagle Summit-Steese Highway
1030-20435	6 - (same)
1033-21011	5 - Tanana River-Murphy Dome transect
1247-20505	5 - (same) plus Fairbanks
1247-20511	5 - (same)
1326-21284	12 - Prudhoe Bay

2. A photographic print was obtained of the southeastern part of scene 1033-21011, in simulated color-infrared, enlarged to a scale of 1:250,000. This was produced from NASA b&w transparencies by photographic personnel in conjunction with project 110-1.
3. A vegetation map, using USGS maps in the 1:250,000 series as base maps, was produced from this print.
4. Two additional prints of a part of scene 1033-21011, including the Tanana River-Murphy Dome transect in test area 5, were obtained, one being an enlargement



Outline map of Alaska showing the general location of the 12 ERTS projects 110-2 and 110-3 test areas in the 148th meridian transect

at a scale of approximately 1:72,360, and the other an enlargement at a scale of 1:63,360. These were made as above, but with the NASA 9 $\frac{1}{2}$ -inch color transparency as the original. Color units, present in remarkable variety and spatial detail, even at so great an enlargement, were delineated on a plastic overlay as the first step in mapping.

5. Two meetings with project 110-2 personnel were held to compare and discuss research problems and results. Vegetation classification and mapping techniques were of chief concern. This investigator proposed that the Fosberg classification be considered for use in Alaska (Reference: Fosberg, F. R. 1961. A classification of vegetation for general purposes. Tropical Ecology 2: 1-28.) The classification developed and applied by the U.S. Forest Service in conjunction with forest survey and inventory work is also being considered.
6. The U of A ERTS investigators met with participants in the recent ERTS symposium to learn about and discuss symposium activities. Discussions also were held with the U of A ERTS computer systems and program specialist regarding a recent trip to see progress on assembly of the digital CDU at Interpretation Systems, Inc., in Kansas.
7. This investigator presented an illustrated lecture on the ERTS program, emphasizing results in project 110-3, to a non-ERTS U of A audience.
8. Near the end of the report period a laboratory assistant was hired. The man, a senior in biology at the U of A, worked for the principal investigator earlier on a different project. He has a strong interest in the ERTS program and its potential. His responsibilities include much of the house-keeping activities, such as air photo and satellite image cataloging, which had required an inordinate amount of principal investigator time, plus some of the more mundane aspects of vegetation mapping, such as application of map unit symbols.
9. NOAA World Aeronautical Charts at a scale of 1:1,000,000 and Sectional Aeronautical Charts at a scale of 1:500,000 were obtained for all of Alaska for use in regional, perhaps state-wide vegetation mapping.
10. On the last day of the report period the principal investigator went to Juneau to begin a nine-day session of study, for ground data purposes, of

large scale air photos in the files of the Institute of Northern Forestry, U.S. Forest Service. This work will be covered in the next report.

11. A tentative selection of non-test area scenes for analysis and mapping was made in lieu of suitable coverage of predetermined test areas. A request to NASA for permission to proceed with these scenes was made by way of a letter to Grover Torbert dated July 25. The scenes chosen were:

- 1009-22090 - lower Noatak River area
- 1009-22095 - western Seward Peninsula
- 1018-21191 - upper Kuskokwim River area
- 1018-21200 - Wood River-Tikchik Lakes area
- 1019-19430 - Juneau-northern Alexander Archipelago area
- 1029-20383 - upper mid-Tanana River area

C. Applicability of ERTS-1 imagery to project objectives

ERTS-1 imagery will permit the identification, delineation and mapping of certain broadly defined vegetation types. This was shown through use of scene 1009-22095 of the western Seward Peninsula, in reconstituted simulated color-infrared format, whereupon five such vegetation types and two vegetation-related phenomena were identified and mapped. It is believed that air photo or field studies, designed on the basis of the ERTS image study, would permit the identification of several more types in this area, as the image used does seem to bear the appropriate spectral detail (Reference: Anderson, J. H. and A. E. Belon. 1973. A new vegetation map of the western Seward Peninsula, Alaska, based on ERTS-1 imagery. No. E73-10305, National Technical Information Service, Springfield, VA. 20 p.) Haugen et al identified four major vegetation types and associated geologic materials and permafrost distribution patterns on scene 1003-21355 covering an area in northwestern Alaska. (Reference: Haugen, R. K., et al. 1972. Cold regions environmental analysis based on ERTS-1 imagery. Cold Regions Research and Engineering Laboratory, Hanover. 12 p.). Studies of scenes 1049-20505 and 1103-20513, covering the Cook Inlet area, show promise for distinguishing healthy spruce vegetation from that infected by the spruce beetle, so long as the infested area exceeds in size the lower image resolution limits. Black and white prints of scenes 1017-21115, 1029-20381 and 1033-21011 covering, respectively, test areas 8, 6 and 5 in interior Alaska, and a color-key image of one of these scenes permit distinction of major vegetation types previously recognized in field studies. It is expected that study of enlarged simulated color-infrared prints, now being prepared, and digital data CRT displays will enable the differentiation of somewhat more narrowly defined vegetation types and the discerning of greater detail in their spatial distribution.

The NASA aerial photography is valuable for interpretation of ERTS images of the test areas. Actual field experience of the principal investigator is limited relative to the size of Alaska, or even of the test areas, and the diversity of vegetation types. Use of the air photos is therefore a matter of economy, and is in accordance with the multistage sampling procedure adopted by this project. In most cases vegetation types and some habitat factors, such as slope, aspect and general soil moisture status, can be determined directly from the aerial photography. The natural color and color-infrared photographs have been used more than the multispectral black and white photographs and infrared scanner imagery to date. Where there is uncertainty in interpretation of aerial photography, field observations may be made.

D. Results

1. Regarding the Tanana River to Murphy Dome transect in test area 5:

This is an intensive training site within test area 5, the Bonanza Creek Experimental Forest-Fairbanks area. The transect includes the experimental forest. It contains a broad range of vegetation-landform types and probably is representative of the interior Alaskan boreal forest.

Standard NASA 9½-inch bulk black and white MSS prints in four bands were examined, using a magnifying glass and strong transmitted as well as incident light. The scene used was 1033-21011. A color-key image also was studied. Both product types were compared with the NASA-Houston aerial photography of the transect and first-hand knowledge of the area.

The color-key image was found inferior to the black and white prints in information content and interpretability. It seems that this product type may not be generally useful.

The band 7 print provided the most vegetation information. Band 6 was nearly as useful, but bands 4 and 5 were of little use in discerning vegetation types, although major roads and a railroad could be seen on these.

On the band 7 print, the most apparent distinction was between spruce-dominated vegetation and all other types. The spruce vegetation appeared dark, whereas the other types were gray to light gray. Spruce stands as small as approximately 100 m in the shortest dimension were easily distinguished. Other vegetation types could also be distinguished at about the same spatial level, although tonal contrasts were more subtle. All major stands of vegetation appearing on the aerial photographs could be discerned on the band 7 print. These included, besides spruce forest, broad-leaved forest, treeless muskeg and bog vegetation, muskeg with scattered spruce, vegetation wherein spruce and broad-leaved trees share dominance, shrub-dominated vegetation, and vegetation comprising herbaceous and dwarf shrub species, primarily at higher elevations.

The tonal differences between some of these was slight, and positive interpretations of units of a given tone could be made only with reference to the aerial photographs. Tonal contrasts were so subtle that a given tone, except for the densest (spruce forest) and the lightest (sparse alpine vegetation), could not be recognized in one place as the same in another. Therefore some form of image contrast enhancement or density slicing, as an adjunct to what the eye alone can do, may be necessary before vegetation identifications, except at the coarser levels of distinction, can be extended over larger areas.

Because of the relatively large amount of vegetation information available on the band 7 print, it is believed that a second print, enlarged to an appropriate scale, might serve for mapping. Interpretations could be facilitated by simulated color-infrared prints of 9½-inch, hence less expensive format, and by CRT displays.

This method of mapping, i.e. tracing on an acetate overlay, could serve some practical purposes, as shown, in part, in the report by Anderson and Belon cited above. Its problems involve image rectification and precise adjustment to given base maps, such as U.S. Geological Survey topographic sheets. There seem to be at least two solutions to this: mapping of small, subareas, one by one, with ongoing adjustments; and use of the zoom transfer scope.

2. Regarding the Eagle Summit-Steese Highway test area, no. 6

MSS black and white prints covering the Eagle Summit Research Area were studied as above in conjunction with aerial photography and field notes.

This area is characterized by treeless shrub and herbaceous tundra vegetation types and areas of sparse vegetation on predominantly rocky surfaces. At lower elevations, in the vicinity of the treeline, stands of shrub vegetation with scattered spruce trees occur.

The band 5 print permitted the easiest distinctions between areas of little or no vegetation and vegetated areas. Ridge crests and high valley side slopes appeared light gray in contrast to the dark grays at lower elevations which predominate in the scene. On band 6 and 7 this distinction is less apparent but may still be made. In all bands the tonal contrast between vegetation containing some, or dominated by spruce trees and other types of vegetation is slight compared to the area examined in 1, immediately above. Positive identifications of spruce vegetation were not possible except by reference to the air photos. This apparent lesser interpretability may be a result of differences in processing between scenes 1029-20381 and 1033-21011.

A possible difficulty in vegetation interpretations in the Eagle Summit-Steese Highway area results from the mountainous character of the terrain - and may therefore arise in the study of many Alaskan scenes. Northeast, north and northwest facing slopes receive sunlight at a considerably lower angle of incidence than flat areas and more or less south facing slopes. This results in large differences in spectral signatures, even though the general vegetation types may be quite similar. There are, of course, many floristic differences and often

structural differences between vegetation on north and south facing slopes. But the general composition and physiognomy is the same in many cases, for given elevations, and therefore is not necessarily distinguishable on ERTS imagery. Because of the low sunlight angles on northerly slopes, these generally appear of medium gray tone, compared to the light medium to light grays of ridge crests and southerly slopes, even at lower elevations. On bands 4 and 5, all tones are relatively darker.

Some areas on northerly slopes are in actual shadow and appear dark, even black in tone, even where no spruce forest occurs, but where sparse vegetation or rock outcrops do. The latter would appear light in tone under direct sun illumination. Tonal differences, reflecting vegetation differences, are the main parameter of an image permitting determination of topography. Nevertheless, the differences here appear greater than can be explained on the basis of vegetation alone.

A possible method for dealing with this problem is discussed under IV F below.

3. Regarding the Wiseman area, test area no. 8

The vicinity of the village of Wiseman was studied on ERTS black and white MSS prints, scene 1017-21115, and compared with aerial photographs and the as yet unpublished results of vegetation studies by this investigator in the area. As in the Eagle Summit area, tonal differences between vegetation types were slight and no positive identifications could be made without reference to air photos or ground data. It seems likely, however, that higher contrast black and white prints of this area could be useful for identification of vegetation types at a similar level as in the Tanana River-Murphy Dome transect. High contrast black and white prints of the Wiseman area, enlarged to a scale of 1:250,000, representing about a three cm square portion from near the center of the image, were obtained through project 110-1.

4. Regarding a few color coded density slice scenes

Color coded density slice scenes were produced by Robert Porter from black and white NASA-Houston aerial photographs of the Eagle Summit area with the image analyzer and CRT equipment of Interpretation Systems, Inc., at Lawrence, Kansas. Several photographs of these were studied by this investigator, but the color patterns were found to bear no relationship with the distribution of vegetation types in the area. However, it is noted that this was only an experimental attempt, using scenes prepared by a person with no particular knowledge of the vegetation of the area.

5. Regarding the mapping activity in test area 5

The following is most of the paper - Boreal forest vegetation map of an area near Fairbanks, Alaska, based on an ERTS-1 image - prepared for presentation at the 24th Alaskan Science Conference in Fairbanks, August 17, 1973. The writer felt free to present these research results in this manner in view of the fact that they were first

presented to NASA in the Fifth Bi-monthly Progress Report, May 31, 1973, and have since appeared as E73-10634 of the NTIS.

INTRODUCTION

This report deals with the making and interpretation of an ERTS-1 image based vegetation map of an area in the boreal forest zone near Fairbanks, Alaska. The image is a reconstituted, simulated color-infrared photographic print of the southeastern part of ERTS-1 scene 1033-21011, enlarged to a scale of approximately 1:250,000. The vegetation map, presented on page 12 at a scale of approximately 1:281,600, depicts the areal distribution of five major vegetation types: needle-leaved forest, broad-leaved forest, scrub, muskeg and bog, and tundra. Mosaics and blends of these types constitute an additional 21 different map units. The map units were established on the basis of visually determined spectral characteristics of the five major plant groups. Some interpretations of the nature of these groups, which could not be made from visually determined spectral information alone, could be made through consideration of available ecological information.

The map area lies a short distance west of Fairbanks (64°50.5' N by 147°43.0' W) and is 48.3 by 64.4 km, or 3,110 km² in size. It includes the Bonanza Creek Experimental Forest of the U.S. Forest Service, Murphy and Ester Domes, and segments of the Tanana River, the Nenana Highway and the Alaska Railroad. The map area comprises a wide variety of habitats and vegetation types, representing much of interior Alaska. These range from lowland muskeg and bogs through several major forest types to the subarctic alpine tundra on Murphy Dome.

The present map is considered only as a prototype of a more refined and accurate 1:250,000 scale vegetation map of the area under consideration. Preparation of the next map could involve electronic digital data processing as an adjunct to direct visual examination of a photographic product. The present map also is considered preliminary to the preparation of a larger scale and more detailed vegetation map, also through visual examination of enlarged photographic products. Such a map, at a scale of 1:72,360, is now under construction.

METHODS

The photographic print used for mapping was produced in the photographic laboratory of the Geophysical Institute of the University of Alaska by a process described by Anderson and Belon (1973) (loc. cit.).

The print was studied for a considerable period in order accurately to discriminate color units, or units of different hue, intensity and brightness, to the extent that accuracy is possible with presumably normal color vision. Strong reflected light and transmitted light were used. Five relatively pure colors were recognized: orange, gray, violet, dull violet and light violet. These occurred as units on the print large enough feasibly to map and label at the scale used in several instances, but often they occurred as mosaics of units too small to map individually. Such mosaics were treated as map units. In addition, a number of map units representing apparent blends of two and three of the

EXPLANATION AND LEGEND FOR MAP, PAGE 12

Boreal forest vegetation map of an area near
Fairbanks, Alaska, based on ERTS-1 imagery

scale approximately 1:281,600

This map was drawn on parts of the U.S. Geological Survey Fairbanks and Livengood topographic maps in the 1:250,000 series. The present scale was obtained through reduction Xeroxing.

B = forest dominated by broad-leaved trees

N = forest dominated by needle-leaved trees

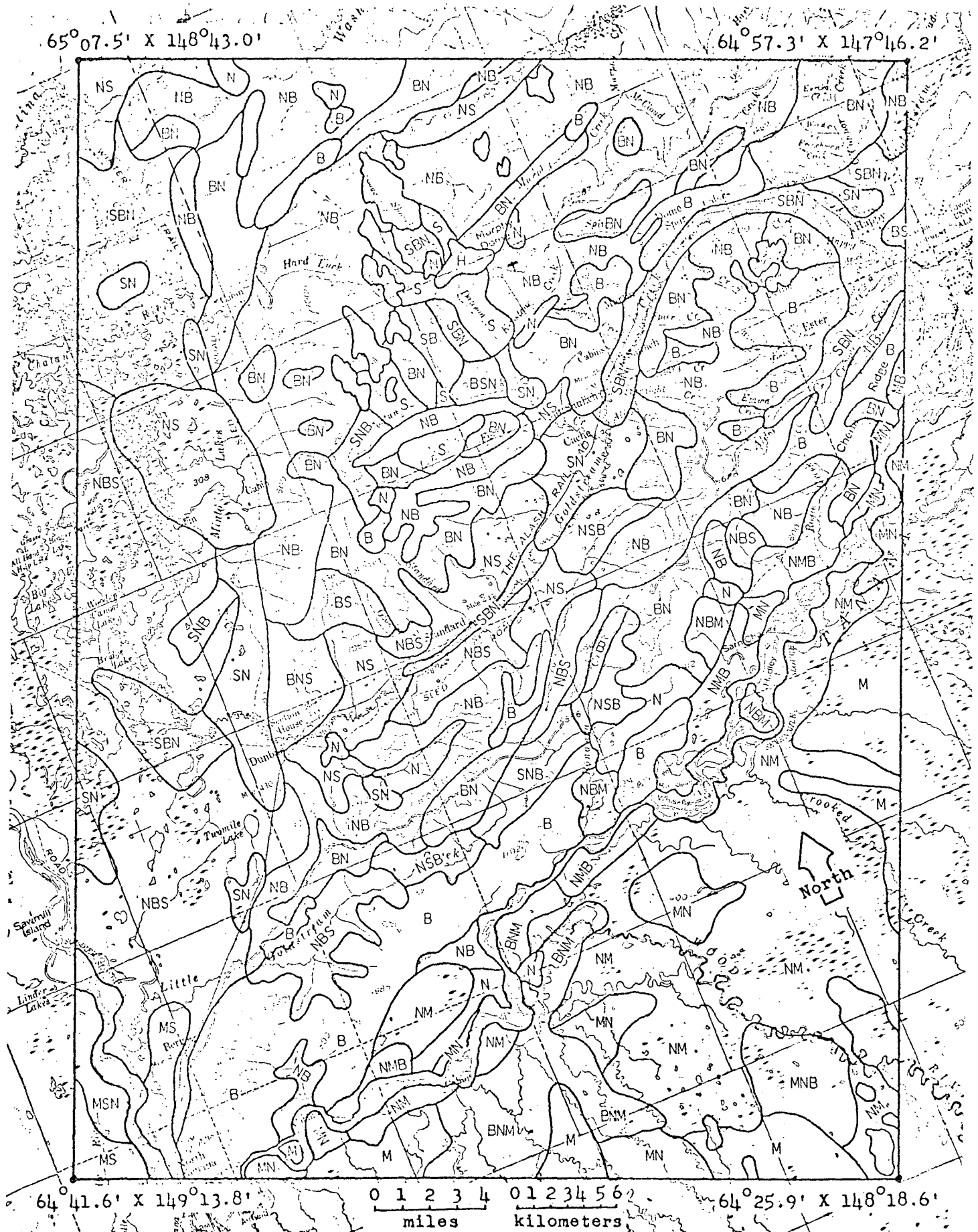
M = muskeg and bog vegetation

S = scrub, vegetation dominated by shrub species

H = vegetation dominated by herbaceous and low-growing
shrub species: tundra

Combination symbols designate mosaics and blends, with letters arranged in order of decreasing apparent importance of the plant components represented. Thus BN = a mixedwood forest dominated by broad-leaved species, with a major admixture of needle-leaved species, and NB = mixedwood forest dominated by needle-leaved species, with a major admixture of broad-leaved species. As a further example, MNB = muskeg or bog vegetation, with a low-density component of needle-leaved species and scattered small stands or individuals of broad-leaved species.

See text pages 13-16.



Boreal forest vegetation map of an area near
Fairbanks, Alaska, based on ERTS-1 imagery
See page 11.

pure colors were established. A total of 26 different mappable color units were recognized, including the five pure colors and 21 mosaic and blend units.

The color units were delineated by drawing on a transparent plastic overlay of the print. The delineations were transferred to a U.S. Geological Survey map in the 1:250,000 series comprising parts of the Fairbanks and Livengood sheets. This was done by placing the U.S.G.S. map over the plastic product on a light table. There was differential scale distortion between these two items, but this was not large within the relatively small map area. Such distortion as there was was ignored on grounds that (a) the vegetation types represented by the mapped color units were so general that the cost of obtaining greater spatial accuracy would not be justified and (b) the work was primarily for training in the interpretation of ERTS imagery and for experimenting with means of transferring information from imagery to a base map. Ultimately, a more accurate, spatially, vegetation map will be produced by the method of tracing on a plastic overlay and then by either (a) transferring the map unit delineations to the base map within small subdivisions of the area, one at a time, with repeated shifting of the base map on the underlying plastic product to maintain spatial coordination or (b) the use of a zoom transfer scope with scale correction capabilities. A zoom transfer scope for transferring information directly from an ERTS image to a base map has been found inferior to the use of a transparent plastic overlay tracing because of the less favorable lighting and focus on the image, hence greater difficulty in recognizing color units and their boundaries. The inability to see at one time more than a small part of an enlarged print in the zoom transfer scope also was found disadvantageous.

It was assumed that the colors on the ERTS image were the direct result of spectral reflectance characteristics of vegetation, since vegetation is known to cover the entire land surface in the map area, with the exception of streams, lakes, roads, gravel pits and a few other man-made features of very minor areal importance. The presence of these was betrayed on the image by certain colors, and these colors could be related to the items they represented on the basis of shape, location and comparisons with existing maps. The spectral characteristics of cultural features generally were quite different from those of vegetation.

Color units were identified according to vegetation type through spot comparisons with aerial photos and consideration of available ecological information. Since these sources, particularly the photos, provided, for sample locations, considerably more information than could ever be discerned on the ERTS image, no field work was done in support of the interpretive and mapping activities.

RESULTS AND DISCUSSION

Five more or less pure colors, to the investigator's eye, were identified and associated with vegetation types. These colors are designated here according to their appearances on the print. It has been found that colors are different on different images: For example, orange on the

print is equivalent to red on the NASA transparency of the same scene.

Orange - forest vegetation dominated by broad-leaved trees;
map symbol B

The species involved in this type are *Populus balsamifera*, *P. tremuloides*, *Betula papyrifera* and a few species of *Salix*. It was not possible to distinguish large and more or less pure stands of single species on the imagery.

Gray - forest vegetation dominated by needle-leaved trees;
map symbol N

The species involved are *Picea glauca* and *P. mariana*. Stands comprising chiefly *P. glauca*, on the one hand, and *P. mariana* on the other could be distinguished with what is considered reasonable confidence, though not on the basis of spectral characteristics. It is well known that the former species prefers relatively well-drained upland sites where the ground water is mobile. It also is the needle-leaved species occurring at the highest elevations. The latter species prefers, or is otherwise restricted to lowland, poorly drained sites. *P. mariana* also occurs on north slopes, where *P. glauca* is infrequent. Thus areas of gray may be identified according to vegetation types dominated by one or the other of these species on the basis of topographic position, slope and elevation. However, it is known also that *P. mariana* sometimes occurs in upland, level or south slope stands and that *P. glauca* may grow in sites normally occupied by the other species. Also, more or less even mixtures of these species are known. Ground data, particularly in the literature, indicates that the distinctions made in this study should be valid in a majority of cases. However, the probability of correct determinations has yet to be established.

Violet - scrub vegetation, dominated by shrub species; map
symbol S

The chief species involved are members of the genera *Alnus*, *Betula*, and *Salix*. Although these could not be distinguished on the basis of spectral characteristics, physical site features recognizable on the imagery, in conjunction with ground and aircraft data, permitted more or less pure stands of these genera to be distinguished. Thus *Alnus*, where it forms stands large enough to be detected by the ERTS system, occurs near major streams on floodplains. *Betula*, including *B. glandulosa* and *B. nana*, the shrub birches, sometimes occurs as a dominant in the lowland, flat muskeg areas and in the shrub tundra above timberline. *Salix* species occur in all of these situations, though usually as a secondary admixture. More or less pure and large stands of *Salix* occur in upland riparian sites and, particularly, in areas where former forest vegetation has been destroyed by fire; certain species of *Salix* are major components of the earlier stages of post-fire vegetation succession. Thus upland areas appearing otherwise suitable for forest vegetation could be identified as possible locations of fires which occurred within the past few decades.

Light violet - herbaceous tundra vegetation; map symbol H

This color was of limited distribution in the area studied, occurring only at and in the vicinity of the highest summit, Murphy Dome. It probably also occurs on one or two of the other highest summits in the area, but these were cloud-covered. The vegetation here is known to be a tundra, characterized by sedges, herbaceous dicots, several species of low-growing woody plants, lichens, mosses and occasional more or less bare rocky areas.

Dull violet - muskeg vegetation and bog vegetation; map symbol M

This color was extensive in the broad, permafrost-underlain "flats" south of the Tanana River in the southern part of the area. This color is believed to represent muskeg vegetation wherein trees are scattered or absent. Here the dominant plants are species of Sphagnum and several other moss genera; Carex; Eriophorum, often forming tussocks; and a number of low-growing shrubs.

The five colors listed above occurred individually as units large enough to map in a minority of cases, although orange is fairly widespread. Usually they could feasibly be mapped at the 1:250,000 scale only as components of mosaics or, in many cases, as blends. For this reason, an additional 21 map units were established, some comprising two and others three colors. These mosaics and blends were identified according to vegetation type, where the type which appeared most important in terms of areal distribution in the mosaics or contribution to the overall color in the blends was listed first. On the map, botanical, instead of color symbols were applied. Thus an orange-gray, equivalent to map unit BN (broad-leaved trees/needle-leaved trees) represents broad-leaved forest vegetation with a major admixture of needle-leaved trees, either more or less evenly scattered - blend - or as scattered relatively pure stands - mosaic. Similarly, a dull violet-gray-orange color represents vegetation characterized by a muskeg plant matrix with a relatively low density black spruce component and scattered individuals or small stands of *Betula papyrifera* and/or *Populus tremuloides*, as along water courses and on raised areas. The map symbol for this is MNB.

This map and the work leading up to it may be of some practical value because (a) it tends to confirm a conclusion from an earlier study (Anderson and Belon 1973) (loc. cit.), involving mostly different vegetation types, that the use of ERTS imagery can enable the inventory and mapping of broadly defined vegetation types over large areas more efficiently than by conventional means, (b) it shows that a similar, larger map for much of interior Alaska could be produced in a few weeks, given availability of comparable imagery for this region, (3) although not a detailed map, the present one is more detailed in both classificatory and distributional respects than any existing published map, and (4) the areas of different vegetation types could be measured with a planimeter and, using factors developed from ground data, e.g. published volume tables, timber biomass might

be calculated for larger areas.

It is clear from this study that, were all the information on the ERTS image, in 9 $\frac{1}{2}$ -inch transparency format, mapped at a scale of, say, 1:63,360, a very crowded map would result. Preparation of a map at this scale, showing the maximum detail in the vegetation cover of the landscape under consideration as is feasible, is the next phase of work in this area. A 16 X 24-inch color print, enlarged to this scale, covering the southern approximately two thirds of the Tanana River-Murphy Dome transect, is available and shows an amazing amount of information expressed as color units.

III. NEW TECHNOLOGY

None

IV. PLANS FOR THE NEXT REPORTING PERIOD

- A. Aerial photography available in the files of various agencies will be studied for additional ground data, both in established test areas and in newly selected areas.
- B. It is increasingly apparent that most of the ground data needed for interpreting ERTS imagery and meeting the objectives of this project may be obtained from aerial photographs. The NASA-Houston air photos are of primary importance, but coverage is limited to a single flight line through the test areas or, in the case of Test Areas 1, 2 and 5, two or three flight lines. Other agencies possess air photos of various dates, spectral characteristics and quality covering the test areas. The U.S. Forest Service and the Bureau of Land Management have especially large collections, including relatively recent photography. Therefore the investigator will continue systematically to search for useful photography and to catalog and study that which is of particular value. This will permit a major reduction in the amount of field work anticipated earlier.
- C. The principal investigator will attempt to learn how to use the digital data color display unit, which is now being installed, and the VP-8 image analyzer. Tapes for two test areas, now available, will then be examined.
- D. The feasibility of transferring vegetation and other ecosystem information on ERTS images directly to 1:1,000,000 scale maps will be explored. It is believed that this might be a suitable scale at which to produce a new, state-wide vegetation map.
- E. Further meetings with project 110-2 personnel will be held.
- F. In mountainous areas, as in test area 6, major spectral differences occur between north and south slopes, sometimes

where the actual landscapes are similar. As discussed earlier in this report, this is a result of the lower angle of incidence of solar radiation on the north slopes and of shadows on the steeper north slopes. In an attempt to develop a technique for identifying similar and dissimilar landscapes under these circumstances, we will experiment with determining interband ratios and, given adequate sequential imagery, signature change relations, using digital data and the CDU.

- G. We will continue to examine closely new imagery, in the hope that some really good scenes or otherwise useful scenes of our test areas will appear, particularly of those areas for which no suitable, growing season imagery is available yet. These are areas 4, 7, 9, 10 and 11.

V. CONCLUSIONS

The principal investigator would prefer to limit conclusions based on work during the report period to the following general statements at this time: (1) The ERTS system is useful for making regional scale studies of broadly defined Alaskan vegetation types. (2) The resolution and spectral information capabilities of ERTS-1 MSS imagery in photographic formats is adequate for certain phytocenologic objectives, including the identification and delineation of major vegetation types, defined on the basis of physiognomically dominant species; determination of the distribution and areal importances of these types; and analyses of certain vegetation-environment relationships, specifically the distribution of vegetation types along elevational, topographic/moisture, and latitudinal gradients. (3) The ERTS system could permit the vegetation and probably ecosystem mapping of Alaska at scales of 1:1,000,000 down to 1:63,360, given the availability of thorough, high quality image coverage, in greater classificatory and spatial detail than was accomplished prior to ERTS. It is noted in this connection that, whereas we've not been too lucky in getting good coverage of our predetermined test areas, good imagery for ^{much} of Alaska is now on hand. By the end of this season there probably will be few, if any remaining gaps. It is also concluded (4) that ERTS imagery is of little value to phenology in interior Alaska because of the rarity of useable repetitive imagery for most places. Finally (5) the second six months' work on this project has shown that certain data handling activities proposed earlier are of little value, including (a) use of color-key images, (b) use of color additive viewer displays and photographs of these and (c) use of precision processed imagery. The most useful product to date has been the simulated color-infrared print, which we can produce fairly economically and with excellent results, starting from the NASA 9 $\frac{1}{2}$ -inch transparency. We have high hopes of increasing our interpretive capabilities through electronic data processing and CRT display, but the ultimate value of this to the present project still remains to be seen. It appears that we can realistically look forward to use of the CDU during the next report period, however.

VI. RECOMMENDATIONS

None

VII. PUBLICATIONS

In preparation

Analysis and mapping of boreal forest vegetation in Alaska using ERTS imagery. In preparation for Photo-Interpretation.

In press

Anderson, J. H. In press. Boreal forest vegetation map of an area near Fairbanks, Alaska, based on ERTS-1 imagery. Proceedings of the 24th Alaskan Science Conference.

Published

Anderson, J. H. and A. E. Belon. 1973. A new vegetation map of the western Seward Peninsula, Alaska, based on ERTS-1 imagery. No. E73-10305, NTIS. 20 p.

Anderson, J. H., L. Shapiro and A. E. Belon. 1973. Vegetative and geologic mapping of the western Seward Peninsula, Alaska, based on ERTS-1 imagery. Proceedings of the Symposium on Significant Results Obtained from ERTS-1, NASA/Goddard Space Flight Center, March 5-9, 1973. p 67-75.

Anderson, J. H. 1973. Letter to the Editor published under the heading "ERTS Imagery." Science 180: 1233-1234.

Note: Material from the paper by Anderson, Shapiro and Belon (1973) was used in the following paper: Maugh, T. H., III. 1973. ERTS (II): A new way of viewing the earth. Science 180: 171-173.

APPENDIX A: CHANGE IN STANDING ORDER FORM

No change

APPENDIX B: ERTS DATA REQUEST FORMS

June 8, 1973. Approved

APPENDIX C: ERTS IMAGE DESCRIPTOR FORMS

See pp 20-21

(See Instructions on Back)

DATE July 31, 1973PRINCIPAL INVESTIGATOR J. H. AndersonGSFC 592ORGANIZATION Institute of Arctic Biology,University of Alaska

NDPF USE ONLY

D _____

N _____

ID _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1247-20505 1247-20511				Bog Braided stream Brush Cartography City Conifer Cropland Deciduous Dormant vegetation Forest Frozen lake Frozen soil Hardwood forest Mature vegetation Muskeg Permafrost Residential area River Road Scrub Snow Snow Pack Timberline Tornado Vegetation

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

MAIL TO ERTS USER SERVICES
CODE 563
BLDG 23 ROOM E413
NASA GSFC
GREENBELT, MD. 20771
301-982-5406

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

DATE July 31, 1973PRINCIPAL INVESTIGATOR J. H. AndersonGSFC 592ORGANIZATION Institute of Arctic BiologyUniversity of Alaska

NDPF USE ONLY

D _____

N _____

ID _____

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1326-21284				Aerial imagery used Airfield Alluvial plain Bay Coast Coastal Plain Delta Dormant vegetation Frozen Lake Frozen Soil Ground truth used Industrial area Mature vegetation Oil Field Permafrost River Road Tundra Vegetation

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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NASA GSFC
GREENBELT, MD. 20771
301-982-5406

APPENDIX D

SEMI-ANNUAL PROGRESS REPORT

UNIVERSITY OF ALASKA
PROJECT 110-3

July 31, 1973

PRINCIPAL INVESTIGATOR: James H. Anderson/UN592

TITLE OF INVESTIGATION: Identification, Devinition and Mapping of
Terrestrial Ecosystems in Interior Alaska

DISCIPLINE: Environment

SUBDISCIPLINE: Vegetation analysis, mapping and phenology

SUMMARY OF SIGNIFICANT RESULTS:

A vegetation map of a 3,110 km² area west of Fairbanks, Alaska, was drawn through use of an ERTS-1 image (NASA ERTS E-1033-21011). Information from the image, a reconstituted, simulated color-infrared photographic print, enlarged to a scale of 1:250,000, was transferred by way of a tracing on a clear plastic overlay to a U.S. Geological Survey topographic map in the 1:250,000 series. The map shows as much detail in the distribution of broadly defined phytocenoses (plant communities) as can feasibly be depicted at this scale, although it doesn't show as much information as is on the image. The mapped area includes part fo the Tanana River flats, the Bonanza Creek Experimental Forest, part of Goldstream Valley, and Ester and Murphy Domes. It therefore comprises a wide variety of phytogeocenoses and may be representative of the Interior Alaska part of the boreal forest biome.

Interpretation of the image involved (a) the identification and delineation of color units, or units of different hue, intensity and brightness, and (b) the relating of these units to phytocenoses or other landscape features where vegetation is sparse or lacking. The color units were identified visually. Because of the inadequacies of the human visual system in distinguishing a large number of subtly different and intergrading colors, only major color categories were identified. However, even at this coarse level of refinement as much information could be mapped as often is accomplished though time-consuming and expensive conventional methods with aerial photographs. The color units were related to phytocenoses by spot comparisons with aerial photographs and the investigator's knowledge of the area. Topographic position, interpretable on the image, was useful in identifying phytocenoses.

Five basic colors were recognized and identified as follows: (1) orange-broad leaved forest; (2) gray - needle-leaved forest; (3) violet - scrub; (4) dull violet - muskeg and bog; (5) light violet - alpine tundra. Although these colors occurred as units large enough to map and label in some cases, often they occurred mixed as mosaics or blends. Twenty-one additional map units were established to accommodate these combinations. Thus dull violet-gray-orange was related to muskeg with scattered or clumped needle-leaved trees and with broad-leaved trees in some areas, as along watercourses. In compound map unit designations the terms were arranged in order of decreasing importance of the plant categories in the vegetation. Mosaics and blends were not differentiated for mapping.

Available information in boreal forest phytocenology makes possible some statements regarding the probable occurrence of major species in the mapped units. For example, needle-leaved forests on upland, more or less south-facing slopes often are dominated by white spruce. In muskeg/needle-leaved tree vegetation, black spruce and occasional admixtures or stands of larch are probably the prevailing arboreal species, whereas sphagnum and other mosses, graminoids and dwarf shrubs may constitute the understory. Accuracy in designation of species or higher taxa varies from one unit class to another because of limitations of satellite imagery. Thus the broad-leaved tree species, chiefly birch and aspen, have not yet been distinguished on spectrophotometric grounds, and they cannot reliably be distinguished on the basis of topographic position.

The map may be of some value because (a) it is an inventory of the broadly defined phytocenoses in the area, (b) it is a prototype of a possibly more refined vegetation map which could be, in the words of A. W. Küchler, "a key to the interpretation of prevailing ecological conditions and the productivity of the landscape", and (c) it shows that vegetation maps of a usefully large scale, i.e. at least 1:250,000 may be produced for large areas through the use of ERTS imagery more efficiently than by conventional methods.